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# Electron Beam Lithography @NanoMicroFab: a powerful tool for research and industrial applications

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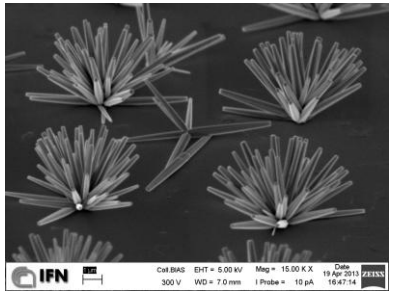
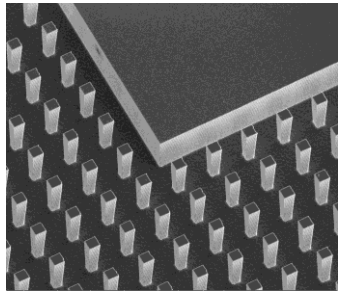
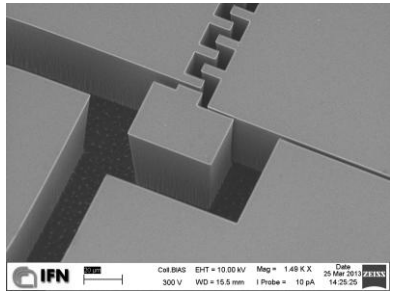
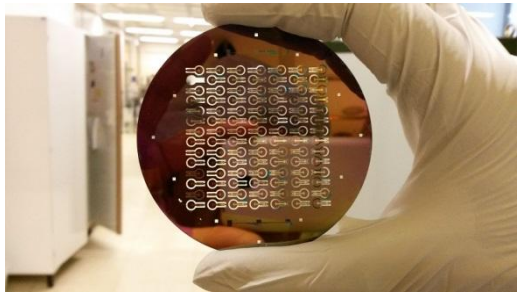
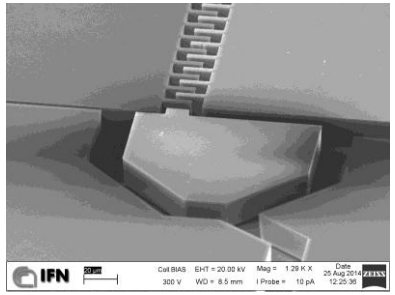
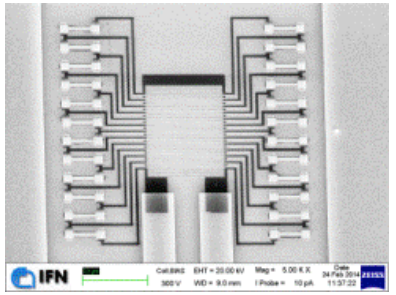
# WHAT

# ELECTRON-BEAM LITHOGRAPHY

E-beam lithography is a tool for **microelectronics, photonics and nanotechnology** in general:

•Direct writing for advanced prototyping of integrated circuits (photonics on GaAs and Si, waveguides, T-gates, etc )
•Research into the scaling limits of integrated circuits and studies on quantum effects and other novel physics at very small dimensions (single electron transistor, quantum wires, finFET, single photon sources, qubits, etc)
•Mask-making, typically chrome-on-glass masks for optical lithography

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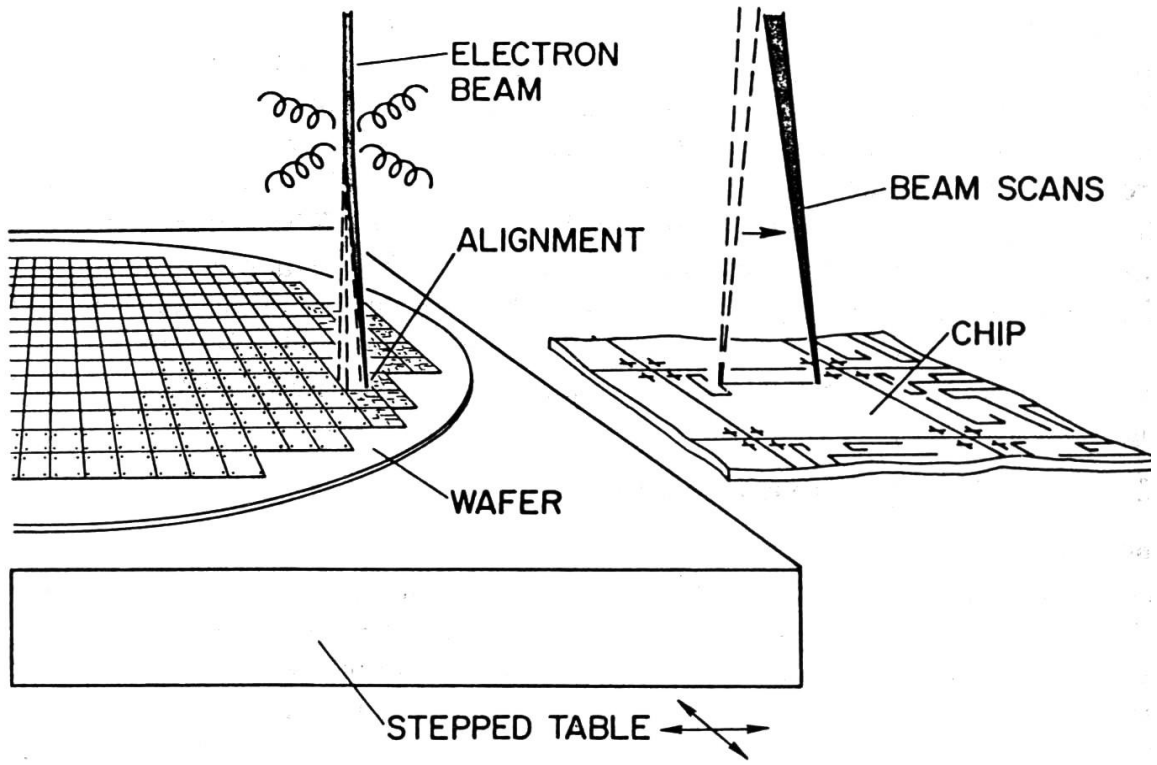
# HOW

# ELECTRON-BEAM LITHOGRAPHY

- The e-beam is directed onto a substrate coated with an electronic resist
- The e-beam is deflected to direct write the chosen pattern
- The main deflection is linked to the acceleration voltage and defines writing field of fixed area




- To write on bigger areas, the stage moves; this movement is controlled by laser interferometer (resolution some nms)

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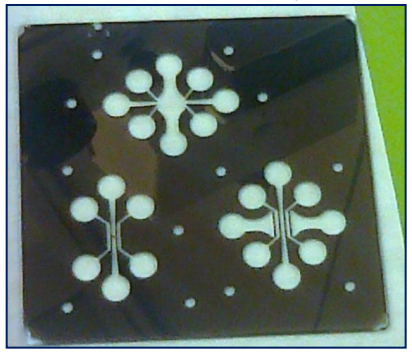
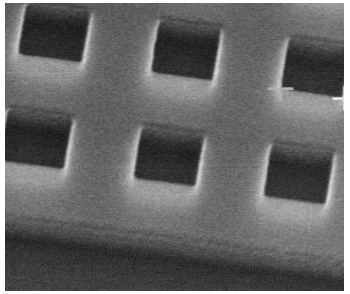
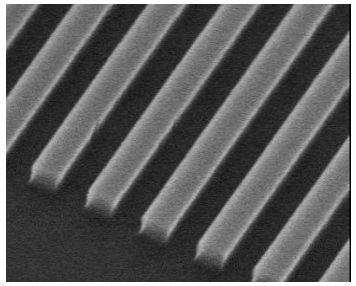
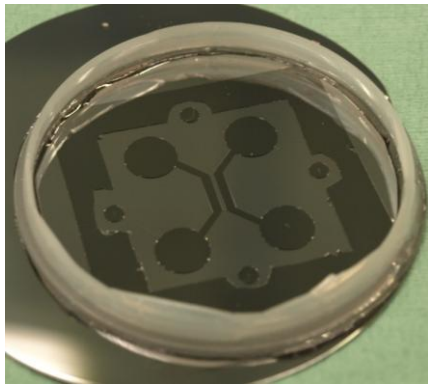
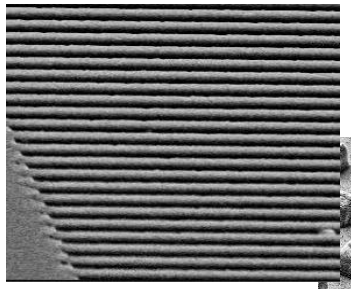
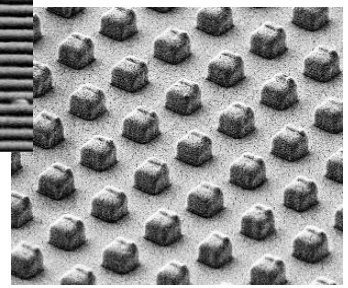
# WHY

## ELECTRON-BEAM LITHOGRAPHY

**EBL** → Serial (pixel per pixel) → Slow but flexible

**Optical and Xray litho**

**Nanoimprint**

→ parallel

Needs MASKs

Needs template

→ High Throughput but fixed pattern

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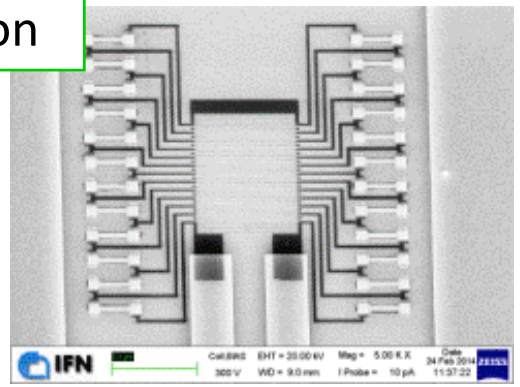
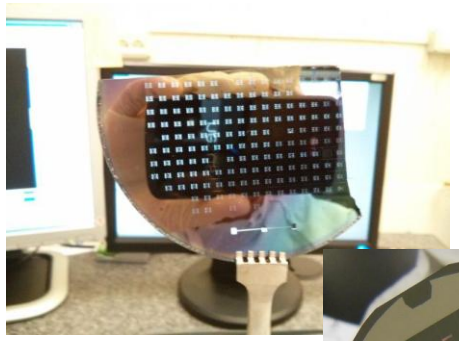
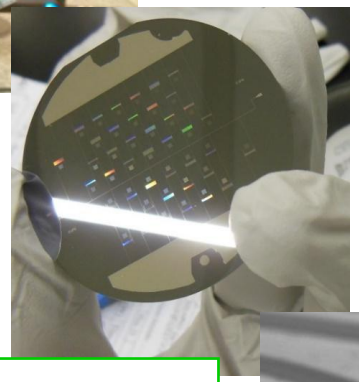
# ELECTRON-BEAM LITHOGRAPHY

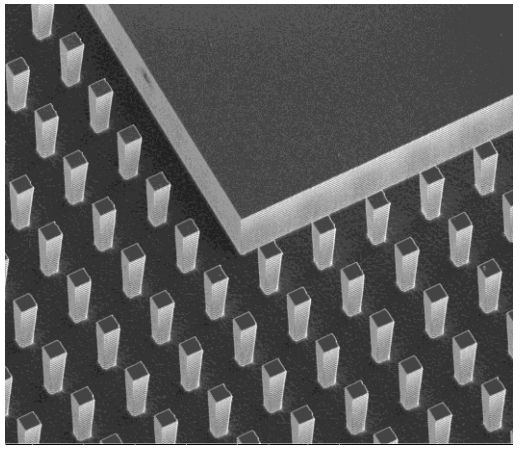
Micro&Nano fabrication



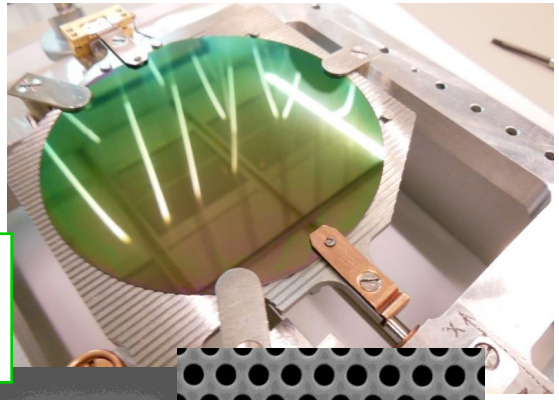





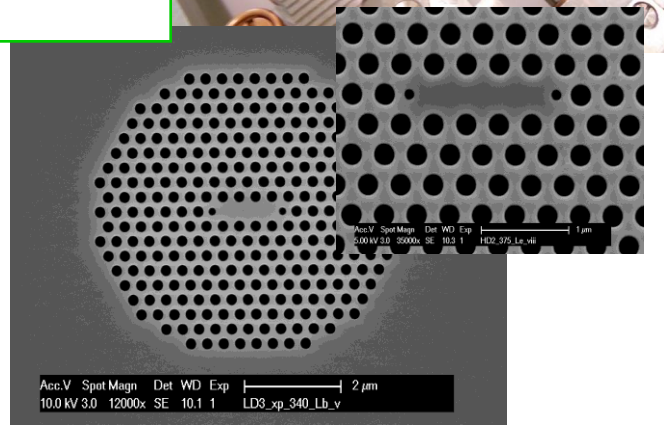
Thin film & micromachining



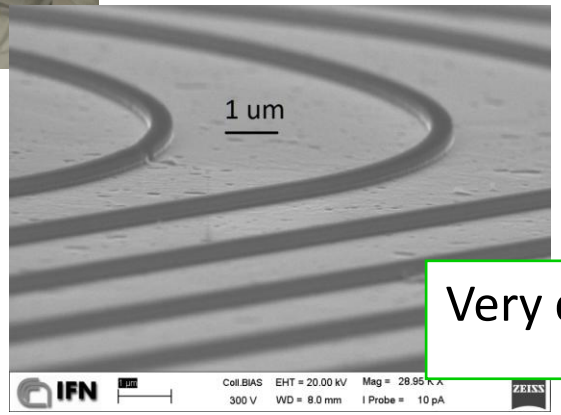
Long time know-how



Single devices & large area processing




High flexibility in processes and procedures




Very different applications!!!

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# ELECTRON-BEAM LITHOGRAPHY

The first e-beam lithography machines, based on scanning electron microscope (SEM), were developed in the late 1960s. Shortly thereafter came the discovery that the common PMMA (polymethyl methacrylate) made an excellent electron beam resist.

**1985 IESS (Istitute of Solid State Electronics)**
**LEICA Electron Beam Mask Fabricator**
**EBMF-10** First e-beam system installed in Italy in a research center.

LaB6 source
**50kV** ( 20kV upgraded )
beam 50nm
PDP 11 computer control
**Dismissed in 2004**

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# ELECTRON-BEAM LITHOGRAPHY

## Raith-Vistec EBPG 5HR
## Installed in 2004 @CNR IFN

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Istituto di Fotonica e Nanotecnologie

- field emission gun FEG
- **100kV**
- beam diameter: 8 nm
- 10 MHz frequency
- block size 560µm
- laser interferometer (λ/120 ~5nm)
- Hight sensor
- overlay accuracy <20nm
- direct writing (up to 4”)
- mask fabrication (up to 4”)
- current: 0,1-100nA

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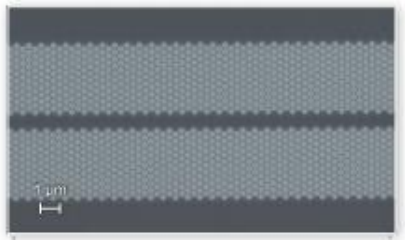
# ELECTRON-BEAM LITHOGRAPHY

RAITH VOYAGER installed in July 2020
@NanoMicroFab

- 50 kV FEG
- Step frequency max. 50 MHz
- Minimum linewidth: <8 nm
- Mask fabrication up to 6”
- direct writing up to 6”
- Sample loading up to 8”

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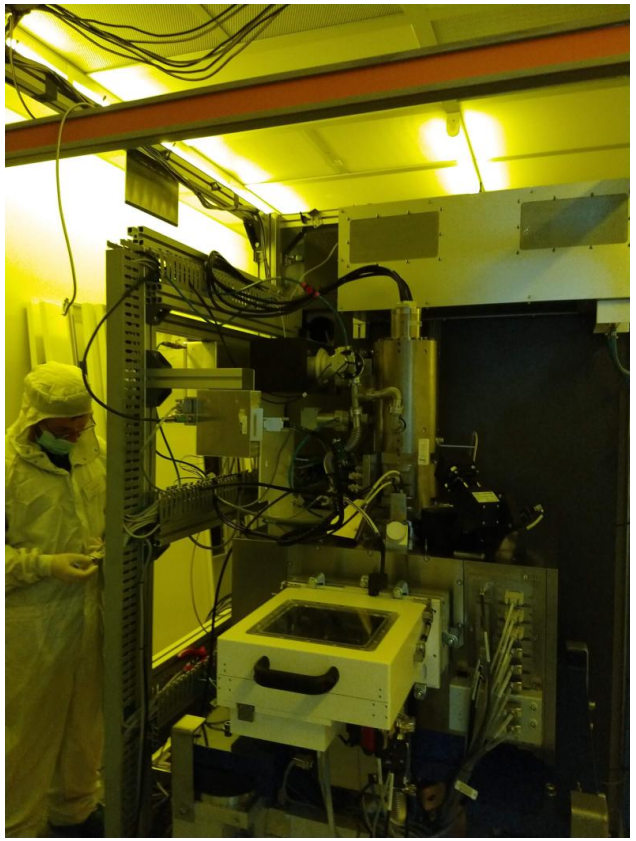
# ELECTRON-BEAM LITHOGRAPHY

## INSTALLATION



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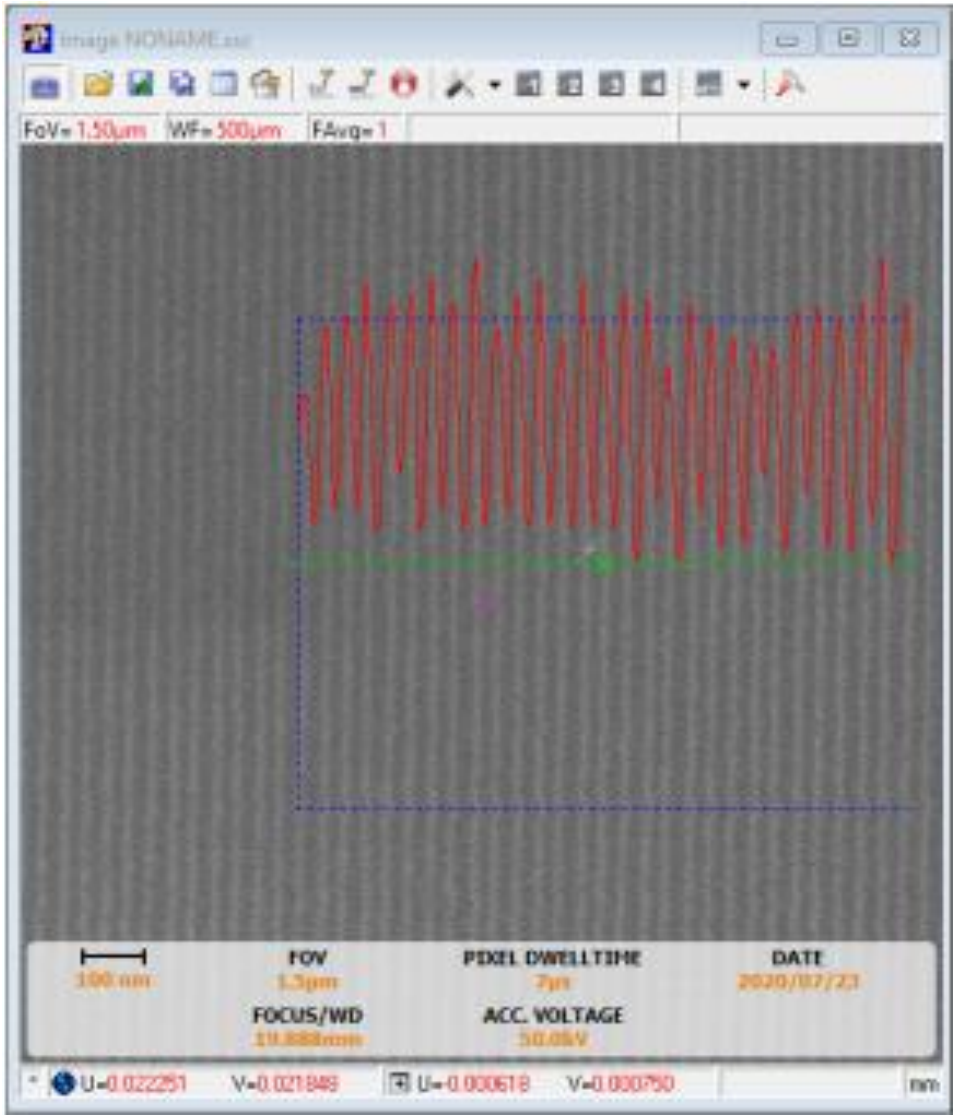
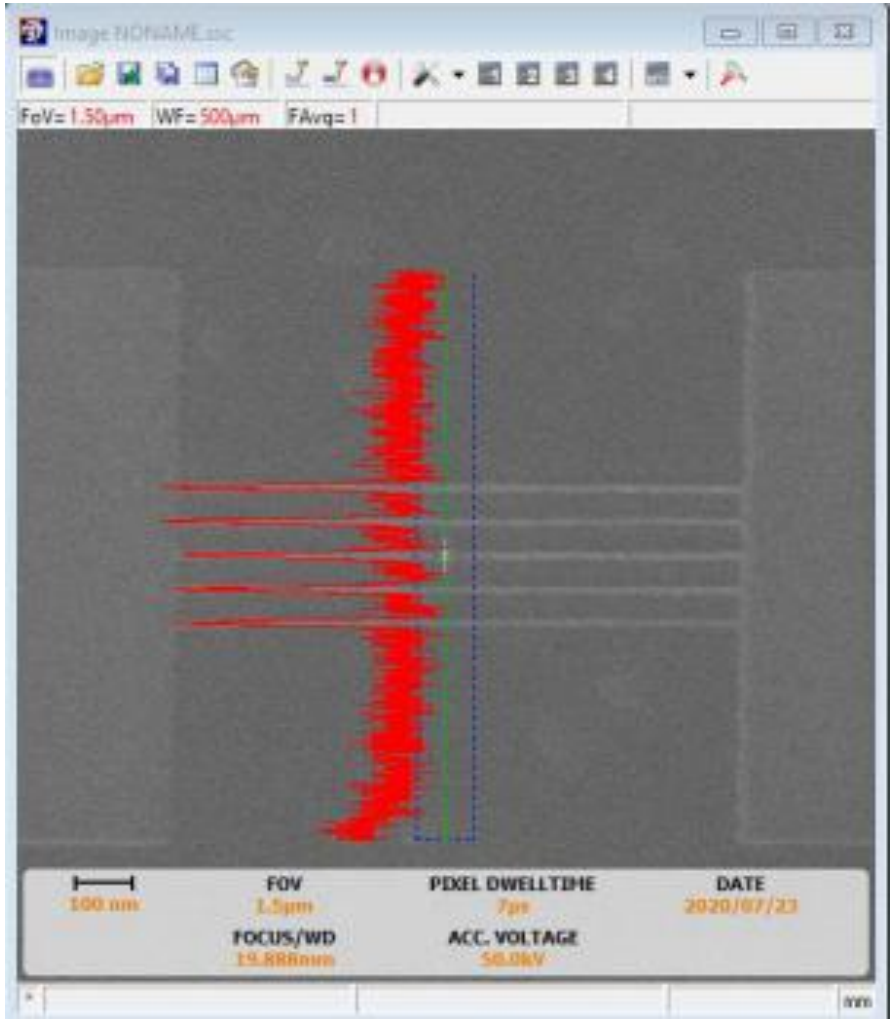
# QUALIFICATION TEST




High resolution result imaged in the VOYAGER at 50kV. PITCH: 35 nm; line: 15 nm

Result of the smallest linewidth test imaged in the VOYAGER at 50kV.



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# WHAT

## ELECTRON-BEAM LITHOGRAPHY

Quantum/ photonics

Detectors

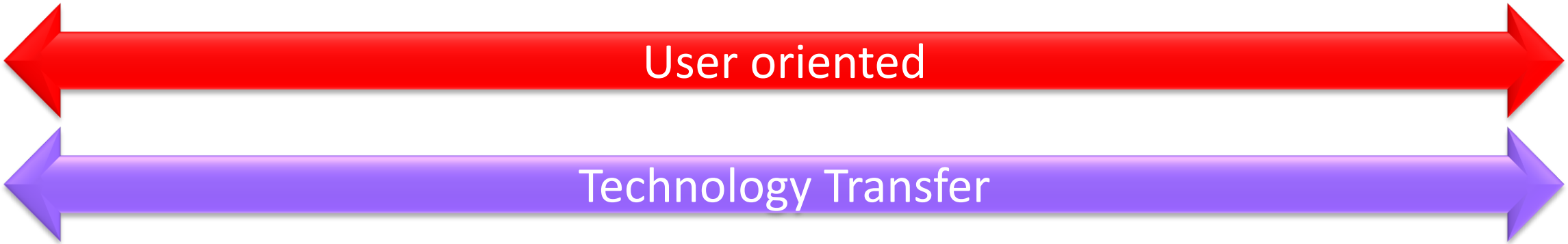
Sensors

Bio

RESOLUTION DOWN TO FEW NM

PROTOTYPING; MIX AND MATCH PROCESSES; HIGH POSITIONING PRECISION; FLEXIBILITY

LAB ON CHIP; POINT OF CARE; MICROFLUIDICS



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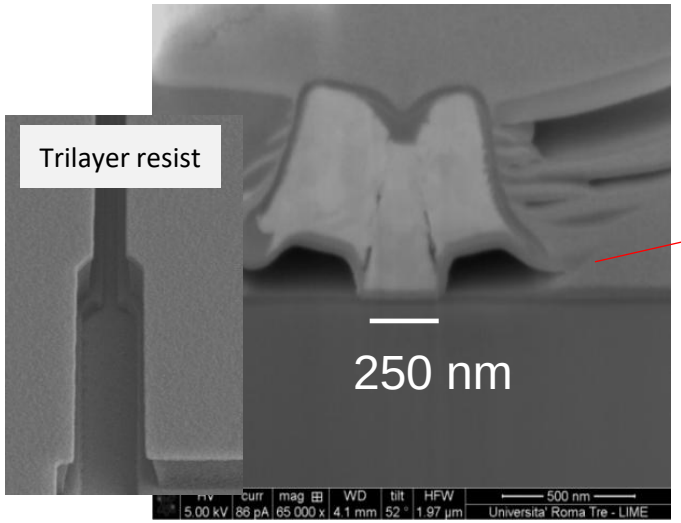


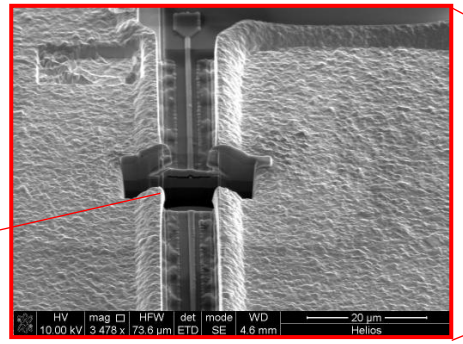

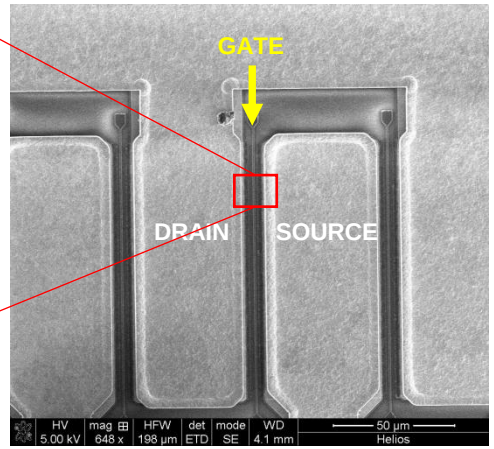


**T-gate** with **Lg = 250nm**
Single e-beam writing
- Trilayer PMMA/COP33/COP8
- EBL
- Development and metallization

HEMT high power amplifiers and/or low noise amplifier for radar applications

- **Collaboration with Leonardo Company**
- **Technology transfer**
- **EBL used as SLX standard process in field-plate technology Lg=250nm**

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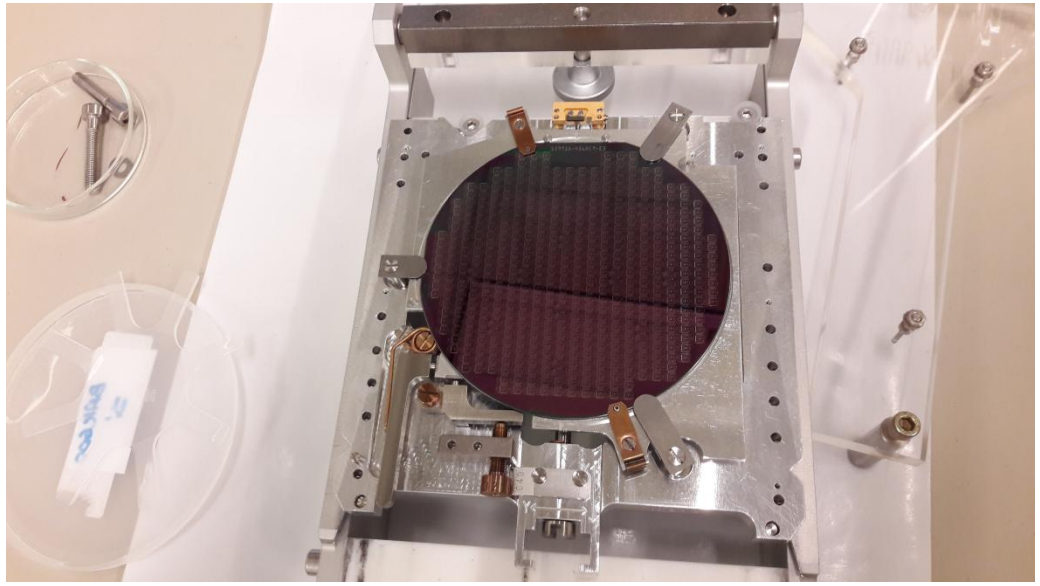
# ELECTRON-BEAM LITHOGRAPHY

- EBPG 5200ES is now in production line
- Totally dedicated to production
- R&D is developed @IFN CNR



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# THANK YOU FOR ATTENTION!

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